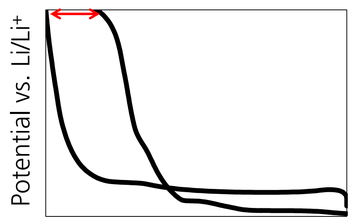
Institut of
Engineering Thermodynamics

Characterization of the Solid Electrolyte Interphase in Lithium-Ion Batteries Depending on the Anode Material

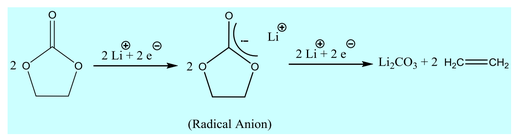
Miriam Klein[1], Norbert Wagner[1], K. Andreas Friedrich[1]

1) German Aerospace Center, Pfaffenwaldring 38-40, 70569 Stuttgart
Correspondance to: **Miriam.Klein@dlr.de**

During the first cycles of a lithium-ion battery a solid interphase forms on the anode side. This is the so-called SEI.



Electrolyte Decomposition



\+
- Protects anode
- Slows down further electrolyte reduction

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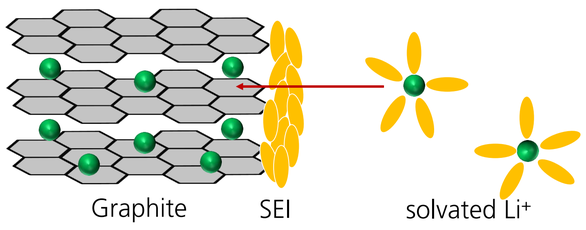
- Causes irreversible capacity fading

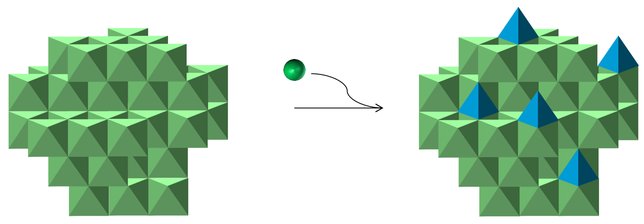
Graphite

- Graphite consists of stacked graphene layers
- Li^+ intercalates
- SEI prevents destruction of the anode by co-intercalation of solvent molecules
- Volume expansion ~ 10 %



Lithium Titanate (LTO)

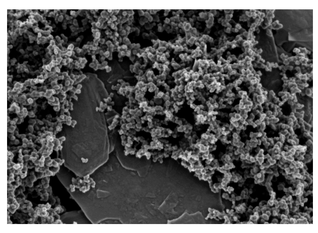
- LTO ($Li_4Ti_5O_{12}$) has a spinell structure
- Lithium occupies tetrahedral sites
- Nearly no volume expansion during lithiation
- SEI formation unclear



Silicon

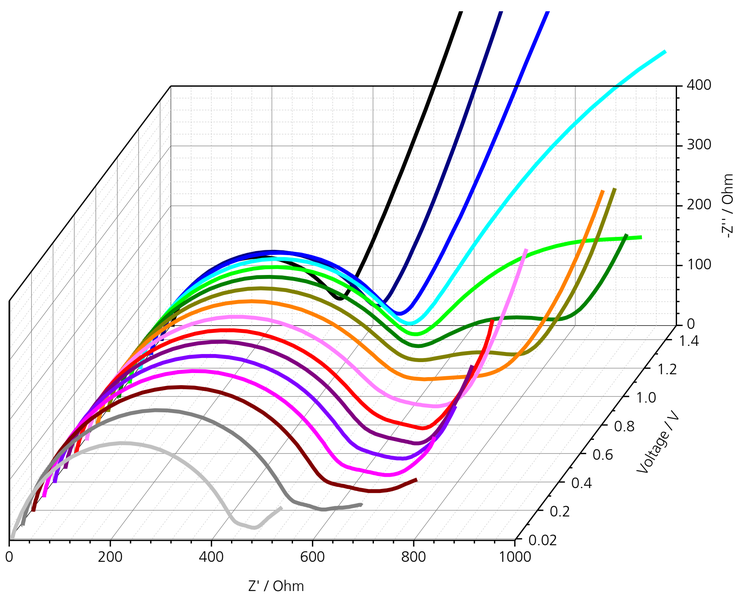
- Silicon forms an alloy during lithiation
- Silicon anode ungergoes a volume expansion of up to 400%
- Continuous SEI formation

Experiments

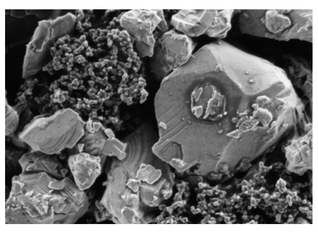


Anode Components:
- Graphite
- Binder
- Carbon Black

- Electrolyte: EC:DEC 3:7 wt.-%, 1 M $LiPF_6$
- Anodes were cycled vs. Li/Li^+ at C/2
- Impedance Spectra were measured during cycling every 0.1 V

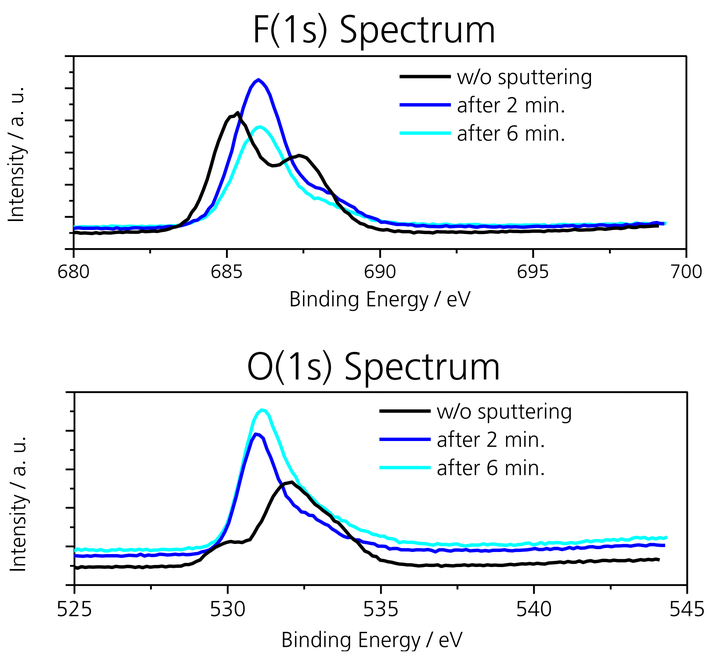


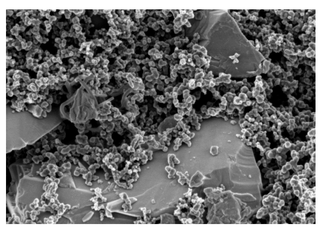
- SEI formation primarily takes place in the first cycle
- Interpretation of the spectra will be done with the help of DRT and EEC



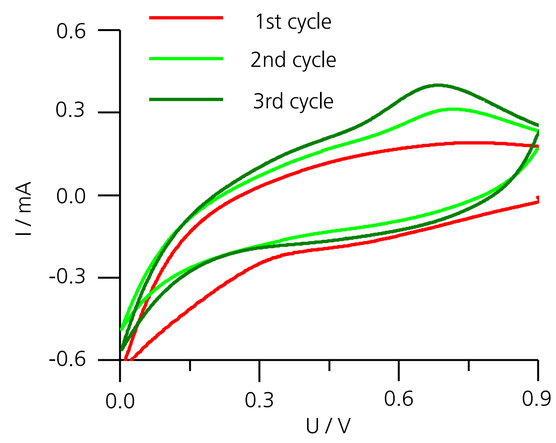
Anode Components:
- Lithium Titanate (LTO)
- Binder
- Carbon Black
- Graphite

- Electrolyte: EC:DEC 3:7 wt.-%, 1 M $LiPF_6$
- Anodes were cycled vs. Li/Li^+ at C/2
- Cycled anodes were dried under Argon atmosphere
- Anodes were characterized by XPS in the original state and after sputtering





Anode Components:
- Silicon
- Binder
- Carbon Black



- Electrolyte: EC:DEC 3:7 wt.-%, 1 M $LiPF_6$
- Linear sweep voltammetry was performed on silicon anode
- There are two main decomposition reactions of EC:
- A single-electron reduction which leads to Li_2CO_3 formation
- A double electron reaction which results in different alkyl carbonates ($ROCO_2Li$)
- SEI is continuosly renewed due to volume expansion

Conclusion

Graphite, LTO and silicon anodes were examined concerning their influence on the SEI formation. On graphite anodes the SEI formatin takes mainly place in the first cycle and prevents anode delamination. XPS spectra of SEI layers on LTO anodes show the existence of fluor components which are present in the used conduncting salt. Silicon anodes suffer from continuous capacity fading as the SEI is renewed constantly due to the large volume expansion.

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